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Q Radial!medical!laser!delivery!device.

Q The present invention involves a medical delivery system capable of emitting radiation with wavelengths between 190 nm and 16! urn in one or more essentially directed, predetermined patterns. It includes at least one solid optical fiber, having a core (2) and a cladding (3) on the core. The cladding has a refractive index smaller than the core, having an input end suitably configured to connect to an appropriate radiation source and having a distal end in the proximity of which two or more grooves (5-7) are penetrating into the core. The grooves have at least partial reflector capability so as to deflect radiation thereto radially in one or more predetermined patterns. The invention also includes methods of performing medical procedures utilizing the aforesaid device.

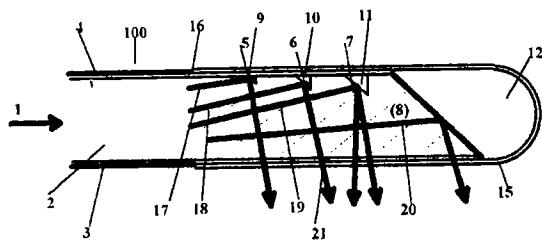


Fig 1

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a laser delivery device, and more particularly to such delivery devices that emit radiation radially from the distal end of an optical fiber.

2. Prior Art Statement

Technological change in laser delivery devices is rapidly taking place in the laser medical field with the onset of minimally invasive procedures such as laser laparoscopy. The laparoscopist, a physician or surgeon who performs laparoscopies, is often challenged with positioning the delivery device, i.e., the optical fiber(s), at angles radially to the laparoscope axis in order to irradiate the target perpendicularly. However, in many cases moving a laparoscope radially is very difficult or is impossible. As an alternative, the laparoscope, which is normally rigid, may have an adjustable fiber deflector called a bridge. The bridge may be adjusted at the proximal end causing radial movements to the distal end of the fibers. This adjustment is, however, limited by the bend radius of the fibers and/or the bridge device and cannot offer full capabilities. Therefore, techniques to emit radiation radially from the distal end of the fiber without bending are needed.

Reflecting tips secured on the distal fiber end, such as metal caps incorporating a mirror surface at a 45° angle relative to the fiber axis are state of the art and have been used successfully in procedures such as lithotripsy with high pulse powered (Q-switched) Yttrium Aluminium Garnet Lasers.

For many surgical procedures requiring an even illumination (such as prostate treatment or photodynamic therapy) the point source-like radiation pattern from this known device is ill suited.

The state of the art devices used in photodynamic therapy incorporate a glue, i.e. epoxy, containing cap with scattering medium dispersed in it. These caps can produce a relatively homogeneous radial pattern. However, the output is diffuse and they are somewhat limited in power handling capability due to the limitations of the glue.

In summary, the present state of the art for radial laser radiation delivery is restricted to either point sources (size of the source comparable to the fiber cross section) or to essentially diffuse radiators with limited power handling capabilities. United States Patent No. 4,740,047 describes a point source type of device using a cut fiber with a reflective surface to deflect a beam for lateral application.

While methods to control the fiber tip temperature aimed at preventing damage to the distal tip of the laser delivery device have been described in United States Patent No. 5,057,099 no control method has been described to prevent or limit damage to the tissue itself that seems applicable to treatments such as laser prostatectomy. Thus, while this recently issued patent allows for temperature control to optimize particular surgical or medical procedures, it does not address or satisfactorily resolve the need for proper lateral and radial delivery of laser beams to satisfy varied needs for varied procedures.

Thus, the prior art neither teaches nor renders obvious the present invention device set forth herein.

SUMMARY OF THE INVENTION

Described is a device capable of delivering high laser power at selected angles or any angle essentially radially to the axis of an optical fiber. The fiber emits the laser radiation from a wider area at the distal end in a well directed, essentially non-diffuse pattern with a plurality of reflective surfaces, having different angles or sizes, within the fiber itself.

Surgical procedures, such as transurethral laser prostatectomy, are beneficially performed using preferred embodiments of the device. The device may comprise feedback control mechanisms from the tissue to regulate radiation delivery dosimetry with procedural requirements.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with further objects, advantages, aspects and features thereof, will be more clearly understood from the following description taken in connection with the accompanying drawings:

Figure 1 is a side view of a radial medical radiation delivery device using air pockets created by the core and a transparent cap for total reflection;

Figure 2 shows another radial medical radiation delivery device that can be freely positioned inside a transparent, inflatable balloon incorporating temperature sensing fibers as well, placed to irradiate the prostate;

Figure 3 is a detailed view of Figure 2 showing reflective metal coating used for deflection;

Figure 4 is a cross section of Figure 3;

Figure 5 shows a conventional state of the art Photo Dynamic Therapy Delivery device;

Figure 6 shows a delivery device with spiral grooves; and,

Figure 7! shows! a! power! control! system! operated! by! sensing! through! the! same! fiber.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

It is an object of this invention to provide a new and improved radial-laser delivery device to overcome the disadvantages of prior radial laser delivery devices, such as power handling capability, area of coverage, extent of coverage, radially directedness of radiation from an extended source, etc. By "radial" and "radially" are meant extending outwardly from the central axis of a fiber and not parallel thereto. In this application, they are meant to include extending outwardly at right angles as well as at any other angles and to include full circumference and only partial circumference radiation.

Another object of this invention is to describe a control mechanism and an improved device method to carry out treatments such as laser prostatectomy and photodynamic therapy.

Figure 1! illustrates a side view of present invention device 100, a typical preferred embodiment of the invention, at its distal end. The optical fiber 1 has a core 2, a cladding 3 and one or more protective coating layers 4. Core 2 is grooved on one side, and grooves 5, 6 and 7 are of increasing size and/or angles, as shown. Core 2 distal end 8 is encapsulated with a protective, transparent cap 15 over a predetermined length so as to cover all the grooves 5, 6 and 7; this resulting in a series of air pockets 9, 10, 11 and 12. The cap can be affixed to the fiber by any medically safe glue 16. If the inclination of the fronts of the grooves (facing incoming radiation) measured from the most inclined ray 17, 18 and 19 travelling in the fiber 1 is chosen such that it is lower than the angle of the total reflection limit between the optical fiber core and air, all rays coming through the fiber from the proximal end (input end of the radiation source, or laser) will be totally reflected and thus exit in radial direction as shown by the typical arrows such as arrow 21.

By progressively increasing the depth of each groove towards the distal end 8 of the fiber 1, more and more radiation is diverted from the axial path into the radial direction resulting in the desired extended directed radiation. This creates a defined, predetermined area of radiation application that is much greater than a reflected point source.

Figure 2! now illustrates how another such device 102 is employed to shrink the prostate gland and thus provide a free passage in the urethra. As known, the prostate gland can swell and thus result in an inconvenience for a high number of men, particularly at higher age, in as much as the ure-

thra is thus partially blocked and the free flow of urine can be obstructed. It is known that by irradiating the prostate, and thus degenerating and shrinking it, this inconvenience can be removed, and a free passage restored. In order to perform this procedure in a controlled and safe manner a present invention radial medical delivery device 102 comprising an optical fiber 31, a multilumen channel 32, an inflatable balloon 33 as well as temperature sensing fibers, such as fibers 34 and 35, is introduced into the urether 35. Fiber 31 has grooves 41, 42 and 43 and cut end 44, as shown. After inflating the balloon that is transparent to the radiation wavelength used in the procedure (example, 1064 nm) radiation is directed at the prostate 36. The inclinations of the grooves 41, 42 and 43 and cut tip 44, vary in this example, so that the radiation represented incoming by arrows 45, 46, 47 and 48, and outgoing by arrows 51, 52, 53 and 54, converges toward the prostate 36.

The radiation is thus effectively penetrating the urether wall 38 in a less concentrated form than it is hitting the prostate, thus limiting the damage done to it.

The balloon 33 can be cooled by gas or liquid to further protect the prostate wall. By feeding the temperature reading obtained via sensing fibers 34 and 35 back to a laser power control, an optimum radiation level can be obtained.

In this example of a preferred embodiment of the radial medical delivery device, the grooves 41, 42, 43 and the cut tip 44 of the distal end 50 of the fiber, shown in part in Figure 3, are at least partially covered by a reflective metal 57, 58 and 59 (such as gold) to deflect the radiation. Dark areas 61, 62 and 63, for example, receive substantially no radiation.

Figure 4! shows a cross section and illustrates how, by flattening the lower side 60 of the fiber 31 focusing in all but the desired dimension and direction may be avoided.

The superiority over the present state of the art will now be clear. Compared to a single reflective (or totally reflective) point source on the end of a fiber the energy density penetrating through the balloon and the urether wall is much lower and a certain degree of focusing can be achieved, if desired, towards the present invention for prostate degeneration. A fiber of synthetic silical could be used to deliver the laser power at 1064 nm. The fiber for sensing the tissue temperature may be of silver halide semi-crystalline material (transmitting a wavelength range between 41 um and 16um).

Any other available or known materials may be used for the fiber for a particular application without exceeding the scope of the present invention. For example, it can be equally possible to make the radial medical radiation delivery device employing

a! silver! halide! fiber! for! the! laser! delivery! itself.

In! this! case! a! CO! or! CO2! laser! can! be! used! as a! radiation! source! with! wavelength! of! around! 5! urn and! typically! 10.6! urn.! In! this! case,! the! same! fiber through! which! the! laser! radiation! passes! for! irradiating! the! tissue! can! also! be! used! to! measure tissue! temperature! as! well,! as! illustrated! in! Figure! 6 and! Figure! 7.

Figure! 6! shows! present! invention! device! 106! a silver! halide! fiber! consisting! of! core! 91! and! clad 92.! In! this! case,! circular! cut! angled! grooves! 93! and 94! and! tip! 96,! as! well! as! a! transparent! cap! 95! are included. While! the! laser! radiation! 116! is! targeted towards! the! tissue! 107,! the! temperature! radiation from! tissue! 108! is! picked! up! by! the! fiber! and transmitted! via! a! reflector! 112! formed! at! tip! 96,! in the! optical! path! of! the! transmission,! and! fed! back as! shown! by! arrow.! As! shown! in! Figure! 7,! this feedback! is! diverted! via! prism! 114! towards! a! laser control module! 122! thus! controlling! the! power! output! of! the! laser! 123! in! line! with! procedural! requirements.

It! is! evident! that! in! some! instances! it! may! be preferable! from! a! manufacturing! standpoint! to! fuse a! tip! of! a! fiber! containing! the! grooves! on! to! another fiber,! thus! effectively! in! the! end! obtaining! a! device similar! in! operational! characteristics! to! the! ones! described! so! far,! and! the! present! invention! device may! include! a! fiber! formed! of! such! joined! sections without! exceeding! the! scope! of! the! present! invention.

Clearly,! in! some! instances! it! may! be! advantageous! to! build! the! delivery! system! of! more! than one! delivery! fiber! processing! the! characteristic! as described! so! far! in! this! invention,! for! instance! in order! to! provide! higher! flexibility! of! the! device while! still! maintaining! a! certain! total! cross! section, a! fiber! bundle! may! be! used,! without! exceeding! the scope! of! the! present! invention.! Such! bundles! may have! fibers! with! identical! configurations! but! slightly staggered! to! enhance! transmission,! or! may! form components! of! a! single! desired! configuration,! depending! upon! the! application(s)! intended.

Obviously,! numerous! modifications! and! variations! of! the! present! invention! are! possible! in! light of! the! above! teachings.! It! is! therefore! understood that! within! the! scope! of! the! appended! claims,! the invention! may! be! practiced! otherwise! than! as! specifically! described! herein.

Claims

1. A! medical! delivery! system! capable! of! emitting radiation with wavelength! between! 190! nm and! 16! urn! in! one! or! more! essentially! directed, predetermined! patterns,! which! comprises:

at! least! one! solid! optical! fiber,! having! a core! and! a! cladding! on! said! core! and! said

cladding! having! a! refractive! index! smaller! than the! core,! having! an! input! end! suitably! configured! to! connect! to! an! appropriate! radiation source! and! having! a! distal! end! in! the! proximity of! which! two! or! more! grooves! are! penetrating into! the! core,! said! grooves! having! at! least! partial! reflector! capability! so! as! to! deflect! radiation thereto! radially! in! one! or! more! predetermined patterns.

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2. A! medical! delivery! system! as! claimed! in! claim 1,! further! characterized! by! a! cap! being! placed over! said! at! least! one! fiber! at! its! distal! end! and over! said! two! or! more! grooves,! and! by! the enclosure! of! gas! pockets! in! the! grooves! by means! of! said! cap.

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10. A! medical! radiation! delivery! device! system! as claimed! in! claim! 1,! which! further! includes! one or! more! temperature! control! sensors! affixed! on to! an! inflatable! balloon! transparent! at! least

4. A! medical! radiation! delivery! system! as! claimed in! claim! 1,! wherein! the! grooves! have! a! reflective! coating! on! at! least! one! side.

5. A! medical! radiation! delivery! system! as! claimed in! claim! 1,! wherein! said! at! least! one! fiber! is! a quartz! glass! or! synthetic! silica! fiber! and! the radiation transmitted! is! between! 180! and 3000nm.

6. A! medical! radiation! delivery! system! as! claimed in! claim! 1,! wherein! the! fiber! is! a! silver! halide fiber! and! the! radiation! transmitted! is! between! 4 urn! and! 16! urn.! In! this! case! the! cladding! on the! core! may! be! air.

7. A! medical! radiation! delivery! system! as! claimed in! claim! 1,! wherein! the! grooves! are! only! on one! side! of! the! device.

8. A! medical! radiation! delivery! system! as! claimed in! claim! 1,! wherein! the! grooves! have! inclinations! which! vary! in! the! device! so! as! to! give! a radiation pattern converging! at! a! predetermined! distance! from! the! fiber! axis.

9. A! medical! radiation! delivery! system! as! claimed in! claim! 1,! which! further! includes! means! for collecting! through! the! fiber,! the! heat! radiation from! the! irradiated! surface,! thereby! controlling the! energy! level! delivered.

10. A! medical! radiation! delivery! device! system! as claimed! in! claim! 1,! which! further! includes! one or! more! temperature! control! sensors! affixed! on to! an! inflatable! balloon! transparent! at! least

over! its! cylindrical! portion! to! the! radiation wavelength! used! and! incorporating! the! radiation! delivery! fiber! in! the! inside! of! said! inflatable! balloon.

11. A! medical! radiation! delivery! device! system! as claimed! in! claim! 10,! wherein! said! fiber! is! located! within! said! inflatable! balloon! in! a! movable! manner.

12. A! medical! radiation! delivery! system! as! claimed in claim! 1,! further! comprising! dosage! monitoring! fibers! affixed! to! an! inflatable! balloon! transparent! at! least! over! an! essential! part! of! its surface! to! the! radiation! wavelength! used.

13. A! method! of! performing! a! laser! prostatectomy procedure,! comprising:

- (a) the! inserting! of! a! cystoscope! into! the urethra
- (b) positioning! a! device! which! includes! at least! one! solid! optical! fiber,! having! a! core and! a! cladding! on! said! core! and! said! cladding! having! a! refractive! index! smaller! than the! core,! having! an! input! end! suitably! configured! to! connect! to! an! appropriate! radiation! source! and! having! a! distal! end! in! the proximity! of! which! two! or! more! grooves! are penetrating! into! the! core,! said! grooves! having! at! least! partial! reflector! capability! so! as to! deflect! radiation! thereto! radially! in! one! or more! predetermined! patterns;! and,
- (c) irradiating! the! prostate! area! to! be! degenerated.

14. The! method! of! claim! 13! wherein! said! device! is further! characterized! by! a! cap! being! placed over! said! at! least! one! fiber! at! its! distal! end! and over! said! two! or! more! grooves,! and! by! the enclosure! of! gas! pockets! in! the! grooves! by means! of! said! cap.

15. The! method! of! claim! 14! wherein! said! device! is further! characterized! by! filling! the! grooves! with a! material! having! a! significantly! lower! reflective index! than! the! fiber! core.

16. A! method! of! performing! a! prostate! degeneration! procedure! comprising:

- (a)! inserting! at! least! the! distal! end! of! a device! into! the! urether,! which! includes! at least! one! solid! optical! fiber,! having! a! core and! a! cladding! on! said! core! and! said! cladding! having! a! refractive! index! smaller! than the! core,! having! an! input! end! suitably! configured! to! connect! to! an! appropriate! radiation! source! and! having! a! distal! end! in! the proximity! of! which! two! or! more! grooves! are penetrating! into! the! core,! said! grooves! having! at! least! partial! reflector! capability! so! as to! deflect! radiation! thereto! radially! in! one! or more! predetermined! patterns;! and,

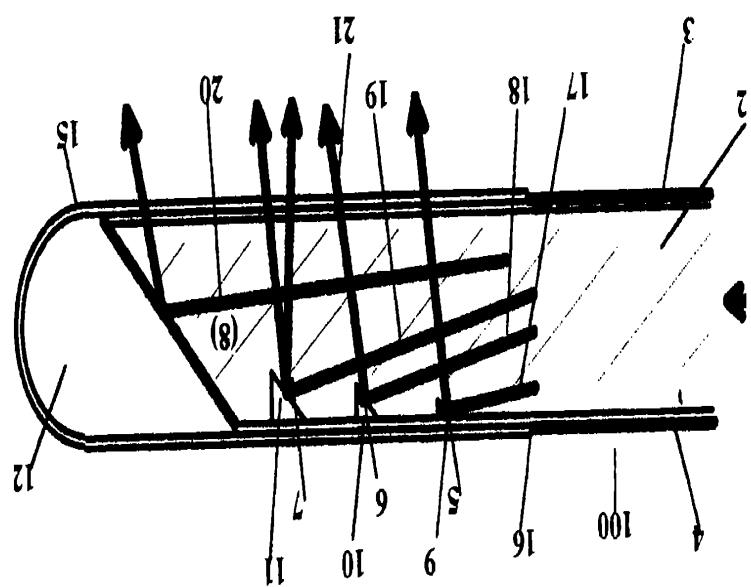
17. The! method! of! claim! 16,! wherein! said! fiber! is located! within! said! inflatable! balloon! in! a! movable! manner.

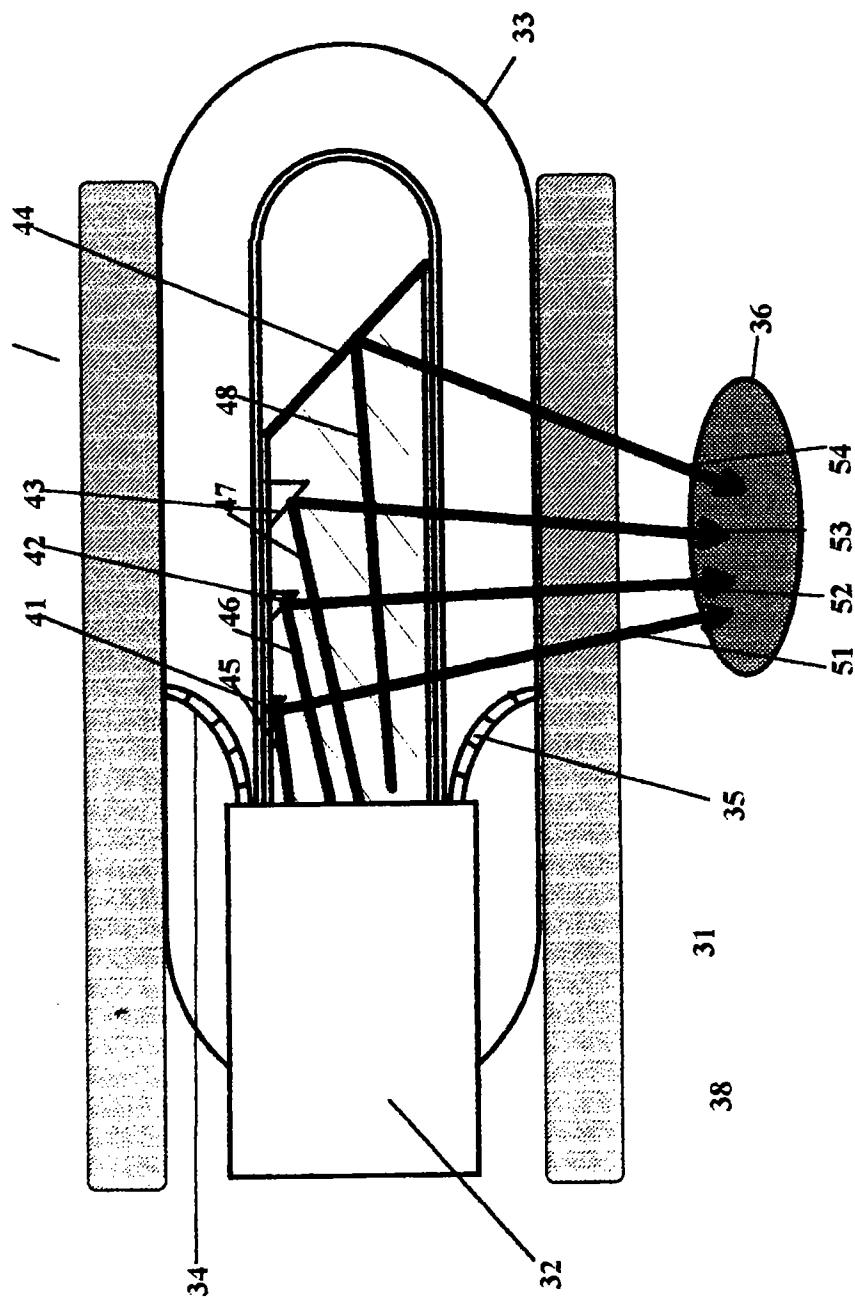
18. Method! of! performing! photodynamic! therapy, comprising:

- (a) applying! a! photosensitive! substance! to the! area! to! be! treated! or! to! the! distal! end! of the! device! set! forth! below;
- (b) inserting! a! device! which! includes! at! least one! solid! optical! fiber,! having! a! core! and! a! cladding! on! said! core! and! said! cladding having! a! refractive! index! smaller! than! the core,! having! an! input! end! suitably! configured! to! connect! to! an! appropriate! radiation source! and! having! a! distal! end! in! the! proximity! of! which! two! or! more! grooves! are penetrating! into! the! core,! said! grooves! having! at! least! partial! reflector! capability! so! as to! deflect! radiation! thereto! radially! in! one! or more! predetermined! patterns;! and,
- (c) irradiating! the! tissue! to! the! intended dosage! level.

19. The! method! of! claim! 18,! further! characterized by! a! cap! being! placed! over! said! at! least! one fiber! at! its! distal! end! and! over! said! two! or more! grooves,! and! by! the! enclosure! of! gas pockets! in! the! grooves! by! means! of! said! cap.

20. The! method! of! claim! 18,! further! characterized by! filling! the! grooves! with! a! material! having! a significantly! lower! reflective! index! than! the! fiber! core.





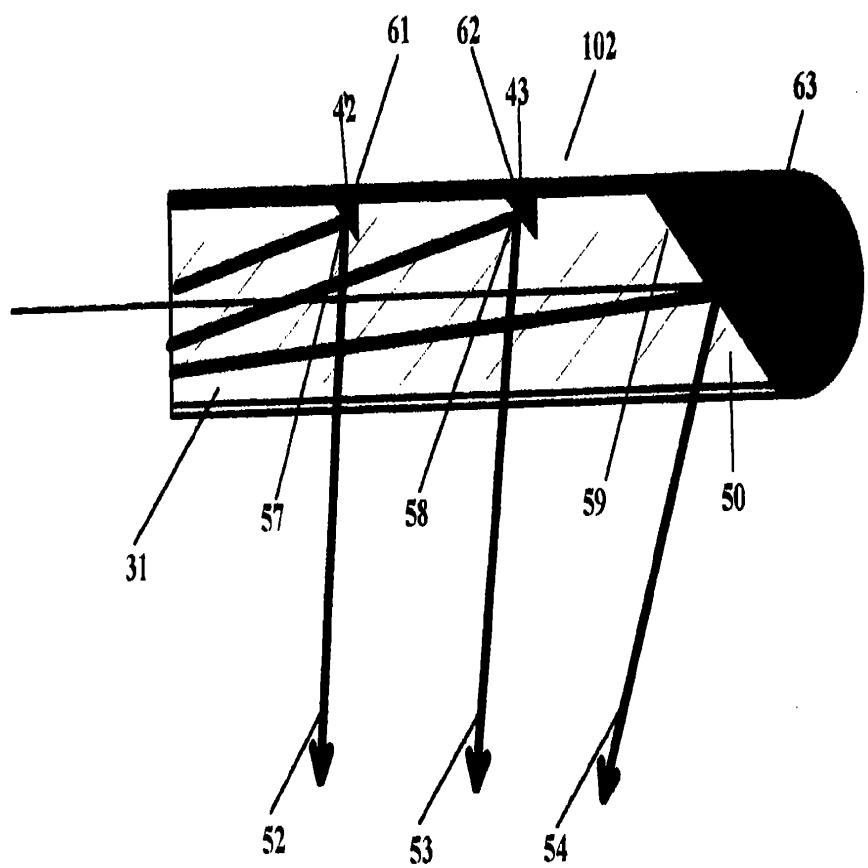


Fig 3

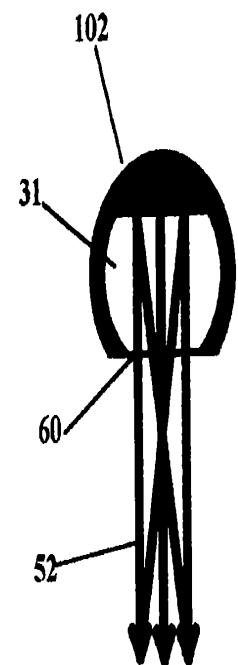


Fig 4

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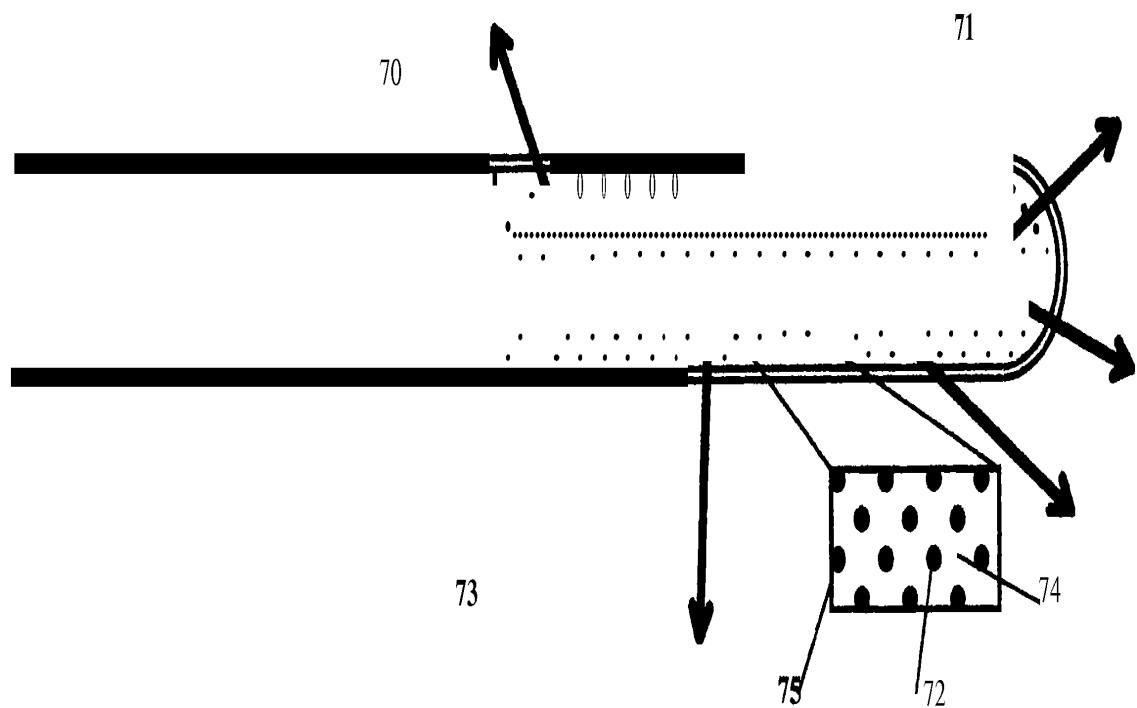
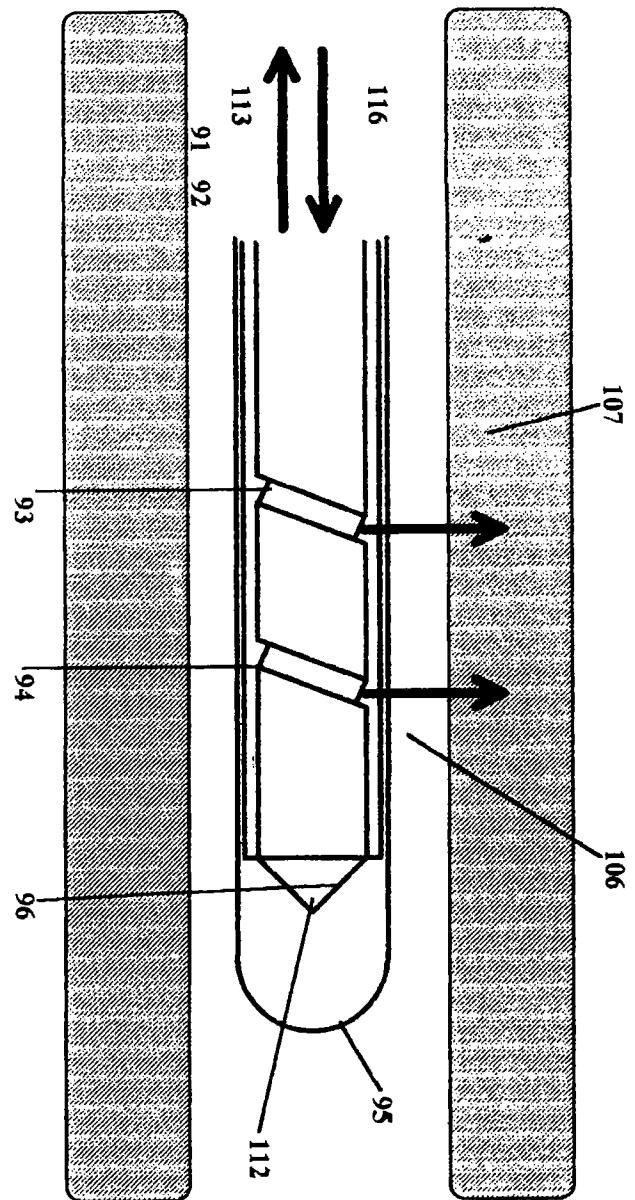
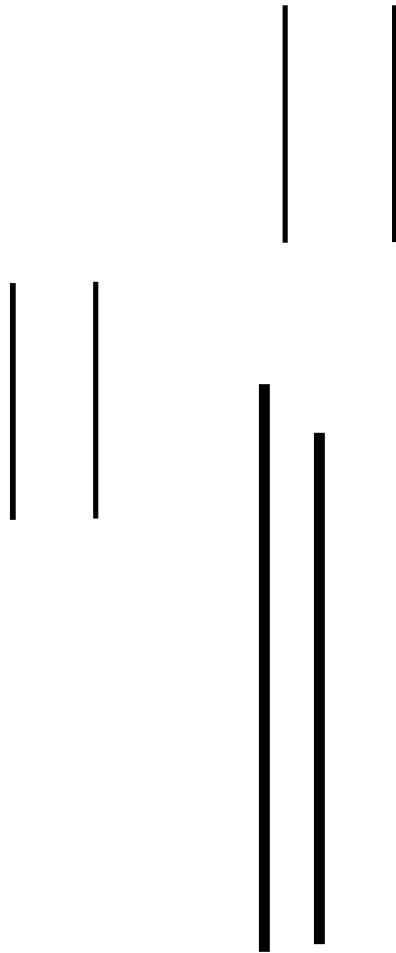


Fig 5



EP 01598 984!AI





European Patent
Office

PARTIAL EUROPEAN SEARCH REPORT

Application Number

EP 93 11 0695

which under Rule 45 of the European Patent Convention
shall be considered, for the purposes of subsequent
proceedings, as the European search report

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.CLS)
A	DE-A-39 26! 353! (K! K! MORITA! SEISAKUSHO) *! column! 10,! paragraph! 3; figures 2C,12B,13H! *	1	A61B17/36 G02B6/28 G02B6/36
A	WO-A-90 02349! (RAYNET) *! figures! 1,4,5,6! *	1	
A	WO-A-91 06251! (SURGILASE) *! page! 5,! paragraph! 3! *	1	
A	EP-A-0 292! 621! (SURGICAL LASER)		
A	US-A-4! 625! 724! (SUZUKI)		
A	EP-A-0 182! 689! (MEDICAL LASER! R&D)		
A	EP-A-0! 073! 617! (PEMBERY)		

TECHNICAL FIELDS SEARCHED (Int.CI.5)

A61B
G02B

INCOMPLETE SEARCH

The Search Division considers that the present European patent application does not comply with the provisions of the European Patent Convention to such an extent that it is not possible to carry out a meaningful search into the state of the art on the basis of some of the claims
Claims searched completely :

Claims searched incompletely :

Claims not searched :

Reason for the limitation of the search:

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Place of search	Date of coayletloa Si the rears	ExaNrr
THE! HAGUE	11! February! 1994	Barton,! S
CATEGORY OF CITED DOCUMENTS		
X : particularly relevant if taken alone	T : theory or principle underlying the invention	
Y : particularly relevant if combined with another document of the same category	E : earlier patent document, but published on, or after the filing date	
A : technological background.....	D : document cited in the application	
O : non-written disclosure	L : document cited for other reasons	
P : intermediate document	& : member of the same patent family, corresponding document	



EP 93 11 0695 -C-

INCOMPLETE SEARCH

Claims searched completely : 1-12
Claims not searched : 13-20